



# New Features of HEC-RAS 4.0

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# New Features in HEC-RAS 4.0

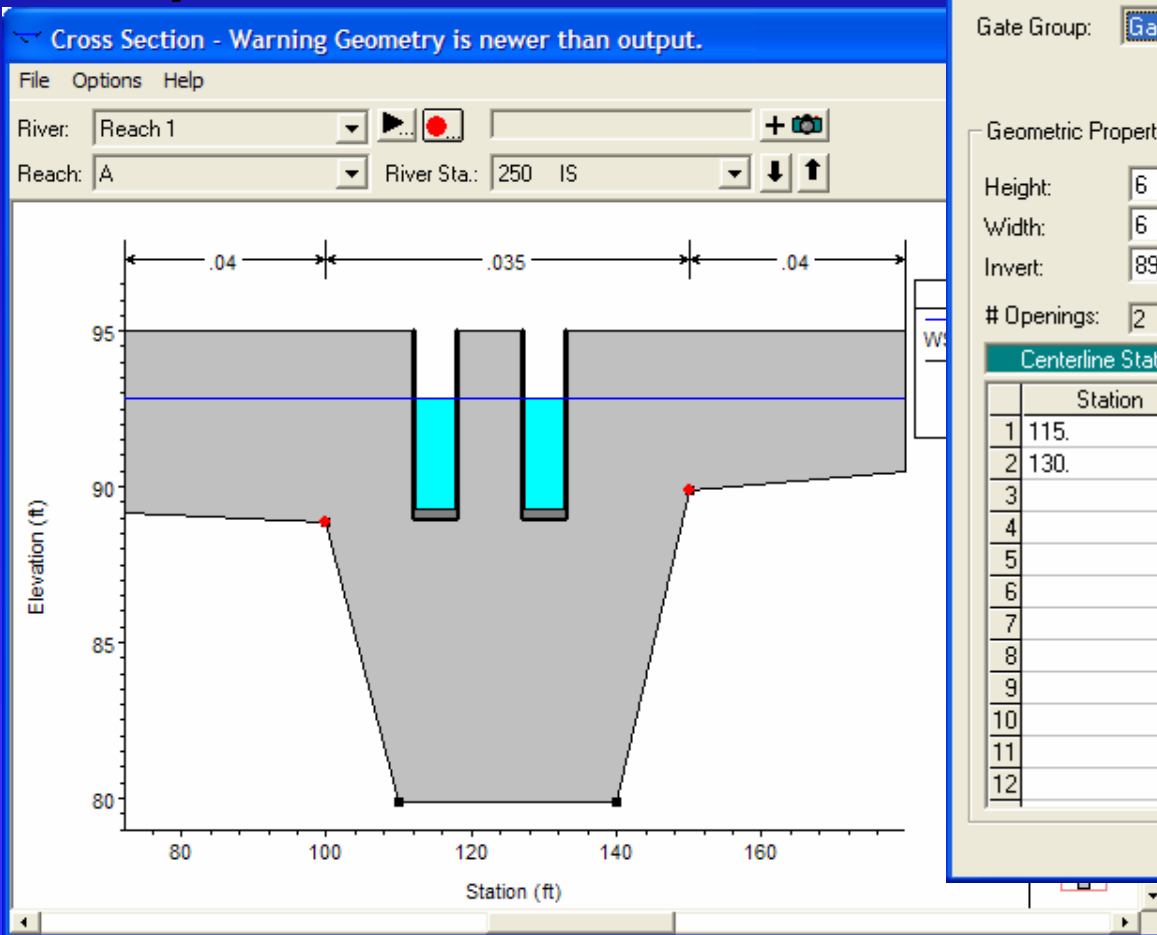
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- **Overflow Gates**
- **User Defined Rules for Gate Operations**
- **Pressure Flow in Pipes**
- **Pump Station Rules**
- **Hager's Lateral Weir Equation**
- **Geo-referencing Tools**
- **Water Quality – Temperature Modeling**
- **Sediment Transport (erosion and deposition)**



# Overflow Gates

- Open Air



## Inline Gate Editor

Gate Group: Gate #1

Gate type (or methodology): Overflow (open air)

### Geometric Properties

Height: 6

Width: 6

Invert: 89

# Openings: 2

### Weir Flow Over Gate

Weir Shape: Sharp Crested

Weir Method: User entered coefficient

Weir Coefficient: 3.2

OK

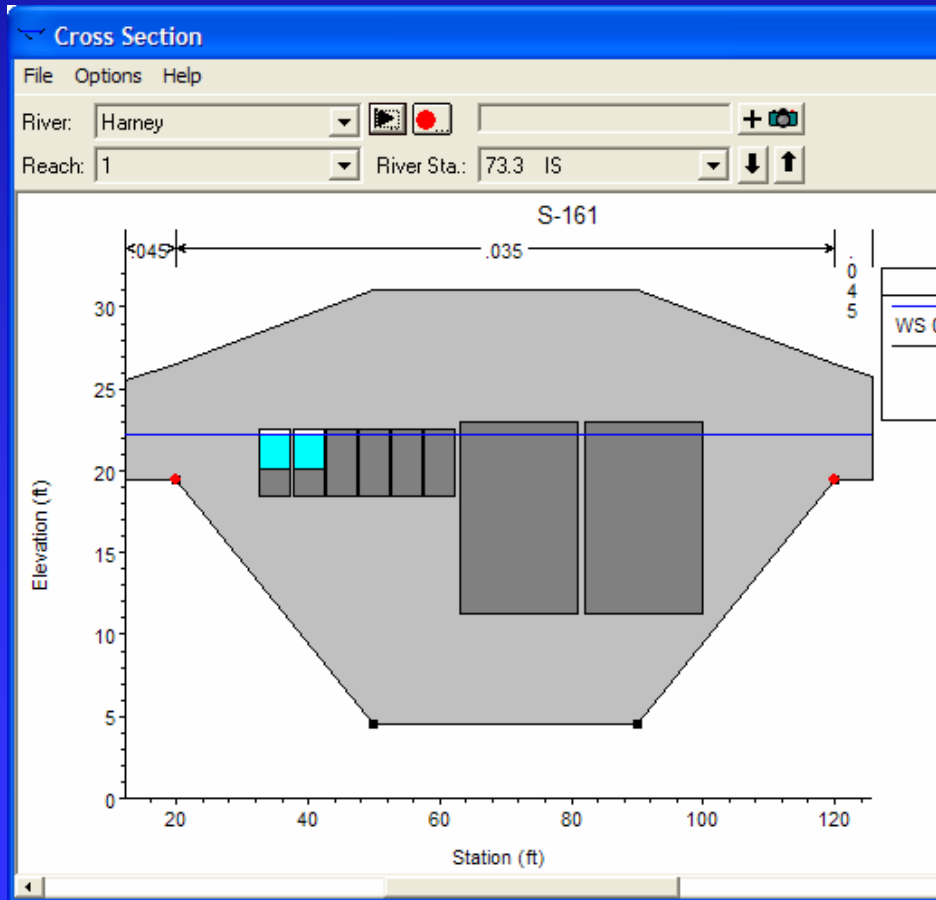
Cancel

Help



# Overflow Gates

- Closed Top



**Inline Gate Editor**

Gate Group: Gate #1

Gate type (or methodology): Overflow (closed top)

**Geometric Properties**

Height: 4

Width: 4.7

Invert: 18.5

# Openings: 1

**Centerline Stations**

	Station
1	35.
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

**Gate Flow**

Sluice Gate Flow

Sluice Discharge Coefficient (0.5-0.7): 0.7

Submerged Orifice Flow

Orifice Coefficient (typically 0.8): 0.8

Head Reference: Sill (Invert)

**Weir Flow Over Gate**

Weir Shape: Sharp Crested

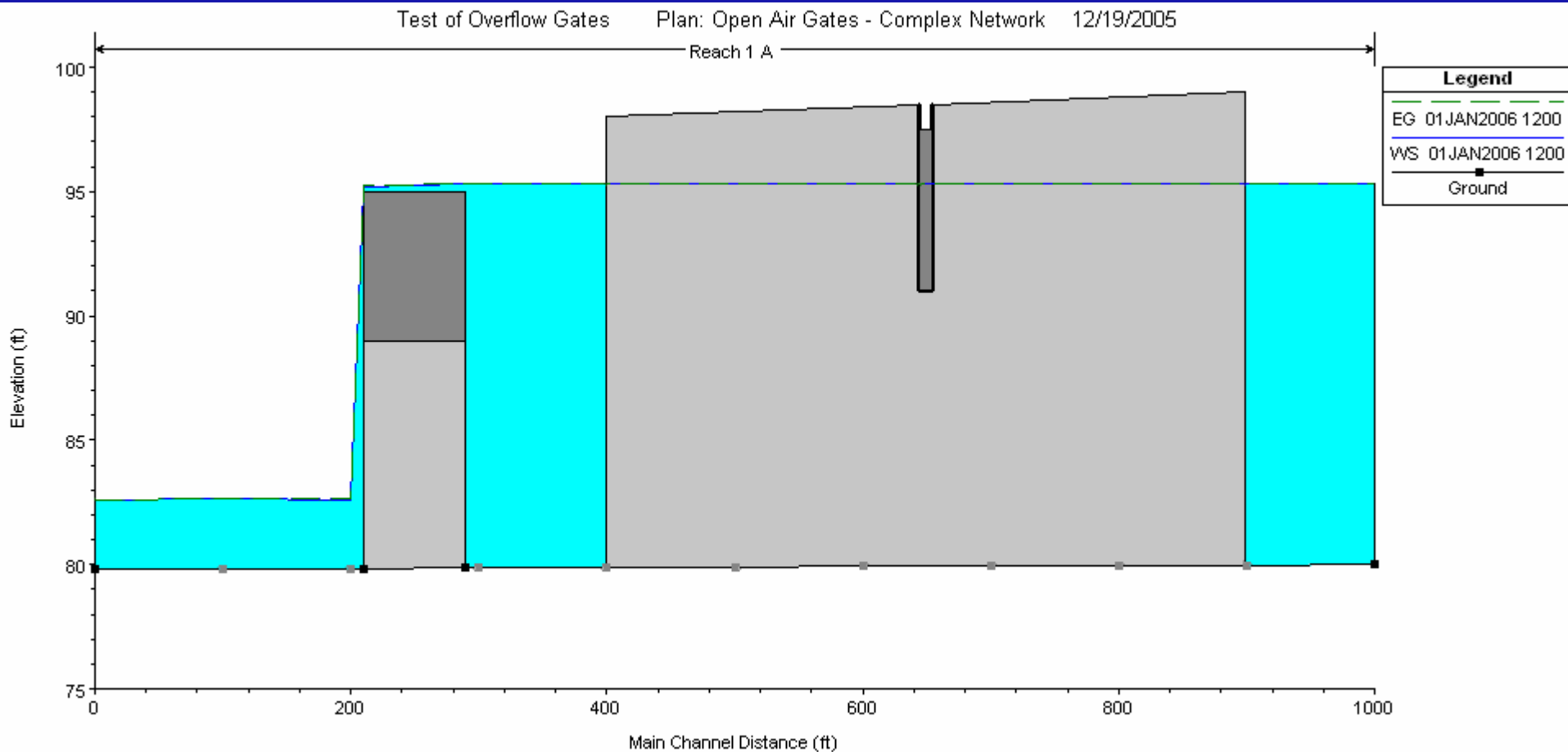
Weir Method: User entered coefficient

Weir Coefficient: 3.27

OK Cancel Help



# Overflow Gates Example





# Operation Rules for Gated Structures

- Unsteady Flow Editor  
“Rules” boundary condition
- Inline/Lateral Structures
- Storage Area Connections
- Controls
  - ♦ Gates
  - ♦ Weir Coefficients
  - ♦ Min/Max Flow
- Rules are evaluated at every time step

Unsteady Flow Data - Unsteady Flow with ND target 22.65 wro

File Options Help

Boundary Conditions | Initial Conditions | Apply Data

Select Location for Boundary Condition

River: CowHouseCk

Reach: 1 River Sta.: 12500 Add a Boundary Condition Location

Boundary Condition Types

Stage Hydrograph	Flow Hydrograph	Stage/Flow Hydr.	Rating Curve
Normal Depth	Lateral Inflow Hydr.	Uniform Lateral Inflow	Groundwater Interflow
T.S. Gate Openings	Elev Controlled Gates	Navigation Dams	IB Stage/Flow

**Rules**

River	Reach	RS	Boundary Condition Type
1 CowHouseCk	1	12500	Flow Hydrograph
2 Harney	1	73.3 IS	Rules
3 Hillsborough	1	605400	Flow Hydrograph
4 Hillsborough	1	605101.*	Lateral Inflow Hydr.
5 Hillsborough	1	605100	Lateral Inflow Hydr.
6 Hillsborough	1	604999 IS	T.S. Gate Openings
7 Hillsborough	1	602447.*	Lateral Inflow Hydr.
8 Hillsborough	1	602400	Lateral Inflow Hydr.
9 Hillsborough	1b	601300	Lateral Inflow Hydr.
10 Hillsborough	1h	601050	Lateral Inflow Hydr.

Storage Area and SA Connections: Add a Boundary Condition Location

Storage Area or SA Connection	Boundary Condition Type
1	

Initial internal water surface elevations set  
Observed DSS data set



# User Defined Rules Editor for Operating Gated Structures

## Operation Rules

Rule Based Operations			
row	Operation	True	False
1	Real 'Tampa Dam Vol since midnight' (Initial Value = 0)	2	2
2	Real 'S-161 Vol since midnight' (Initial Value = 0)	3	3
3	Real 'S-161 Vol Diversion'	4	4
4	'Tampa Dam 4 Hour Ave Flow' = Inline Structures:Structure - Total Flow (Fixed)(Hillsborough,2,600042,Average over previous time window,4,0)	5	5
5	'Time Step hours' = Solution:Time Step(Value at current time step)	6	6
6	'Time Step seconds' = 3600 * 'Time Step hours'	7	7
7	'Tampa Dam Flow' = Inline Structures:Structure - Total Flow (Fixed)(Hillsborough,2,600042,Value at current time step)	8	8
8	'S-161 Flow' = Inline Structures:Structure - Total Flow (Fixed)(Harney,1,73.3,Value at current time step)	9	9
9	'Tampa Dam Vol since midnight' = 'Tampa Dam Flow' * 'Time Step seconds' + 'Tampa Dam Vol since midnight'	10	10
10	'S-161 Vol since midnight' = 'S-161 Flow' * 'Time Step seconds' + 'S-161 Vol since midnight'	11	11
11	'Day Beg time step' = Time:Day of Month(Beginning of time step)	12	12
12	'Day End time step' = Time:Day of Month(End of time step)	13	13
13	If ('Day Beg time step' <> 'Day End time step') Then	14	50
14	'HR 24hour ave Flow' = 'Tampa Dam Vol since midnight' + 'S-161 Vol since midnight' / 86400	15	15
15	'Tampa Dam Vol since midnight' = 0	16	16
16	'S-161 Vol since midnight' = 0	17	17

Insert New Operation

Comment    New Variable    Get Sim Value    Set Operational Param    Branch (If/Else)    Math    Table

Current Operation Changes

Copy    ↓    ↑    ✕    ☐ Disable

Get Simulation Value

Assign Result

☐ Existing Variable

☒ New Variable

S-161 Flow

=

Inline Structures

- Structure - Total Flow (Fixed)
- Structure - Total Flow (Desired)**
- Structure - Flow Additional**
- Structure - Flow Maximum**
- Structure - Flow Minimum**
- Structure - Total Gate Flow
- Structure - Total Gate Flow Maxi**
- Structure - Total Gate Flow Mini**
- Structure - Gate Monitor Setting

Set Node Location

River: Harney

Reach: 1

RS: 73.3 IS

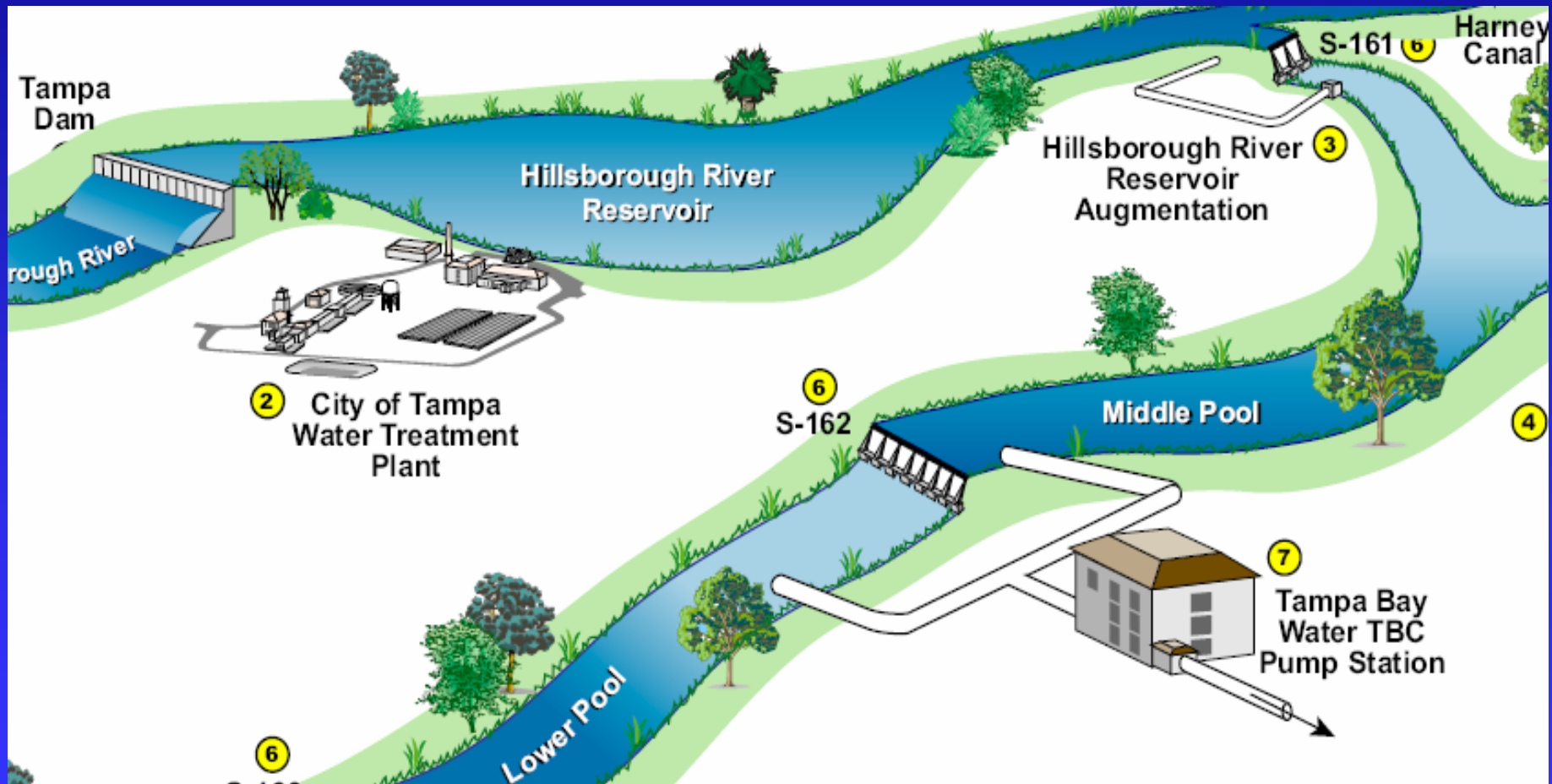
Value at current time step

(Simulation variables in bold are only available for the current structure)

OK    Cancel



# Tampa Bay Water System Overview







# TBW S-161 Diversion Structure Rules

- Get previous 24 hour outflow
  - ♦ Outflow includes Tampa Dam & S-161
- Determine allowable diversion:

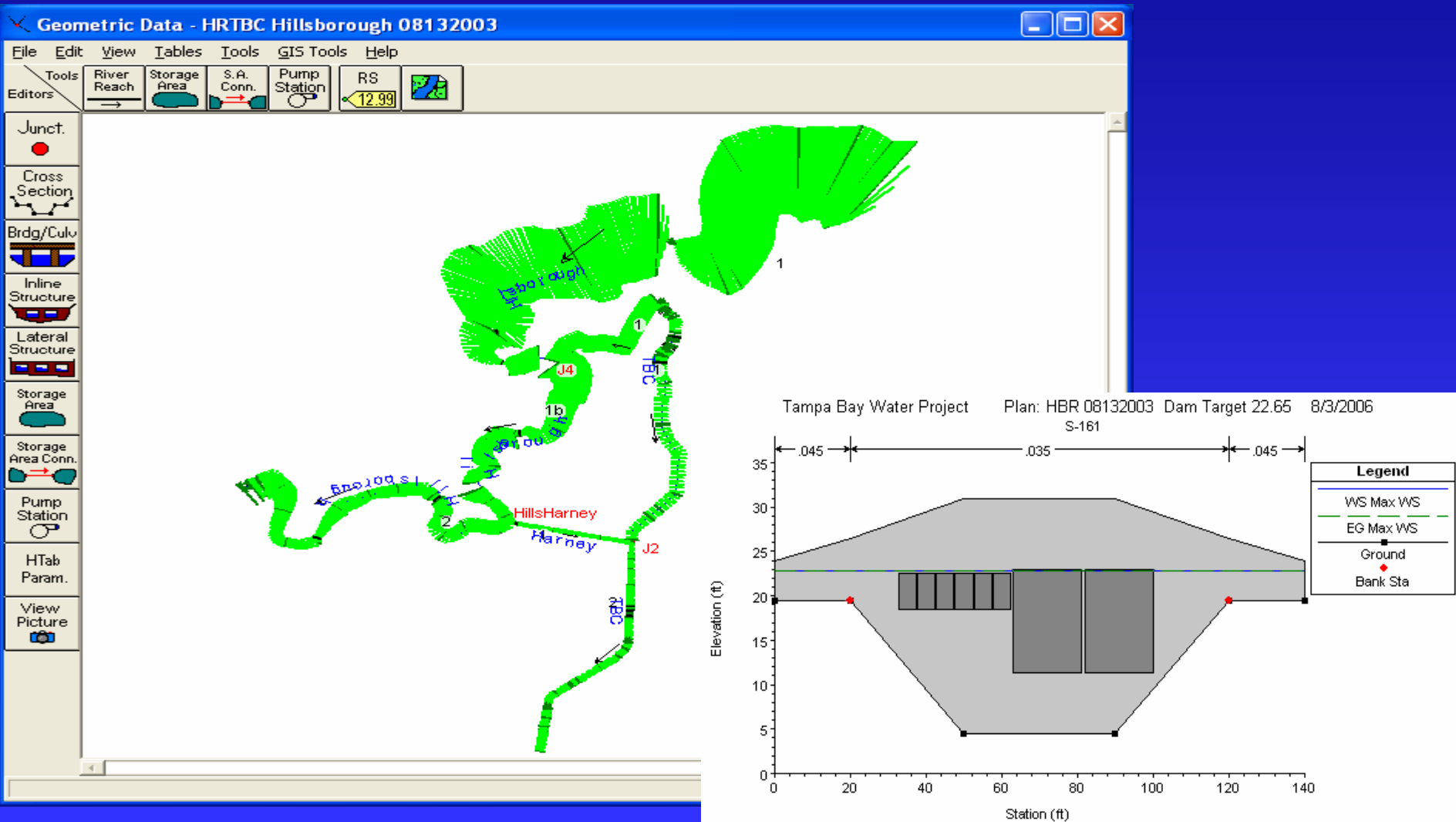
<i>Discharge at Tampa Dam (mgd)</i>	<i>Withdrawal from Middle Pool (mgd)</i>
Less than 65	0
65-97	10% of the discharge at Tampa Dam
97-139	10-30% of the discharge
139-647	30% of the discharge
More than 647	194

- Adjust S-161 gates to get allowable diversion in ~20 hours
- Close gates when/if:
  - ♦ Maximum volume diverted
  - ♦ 4 hour running average at Tampa Dam  $< 10\text{cfs}$



# Animation of Gate Operations

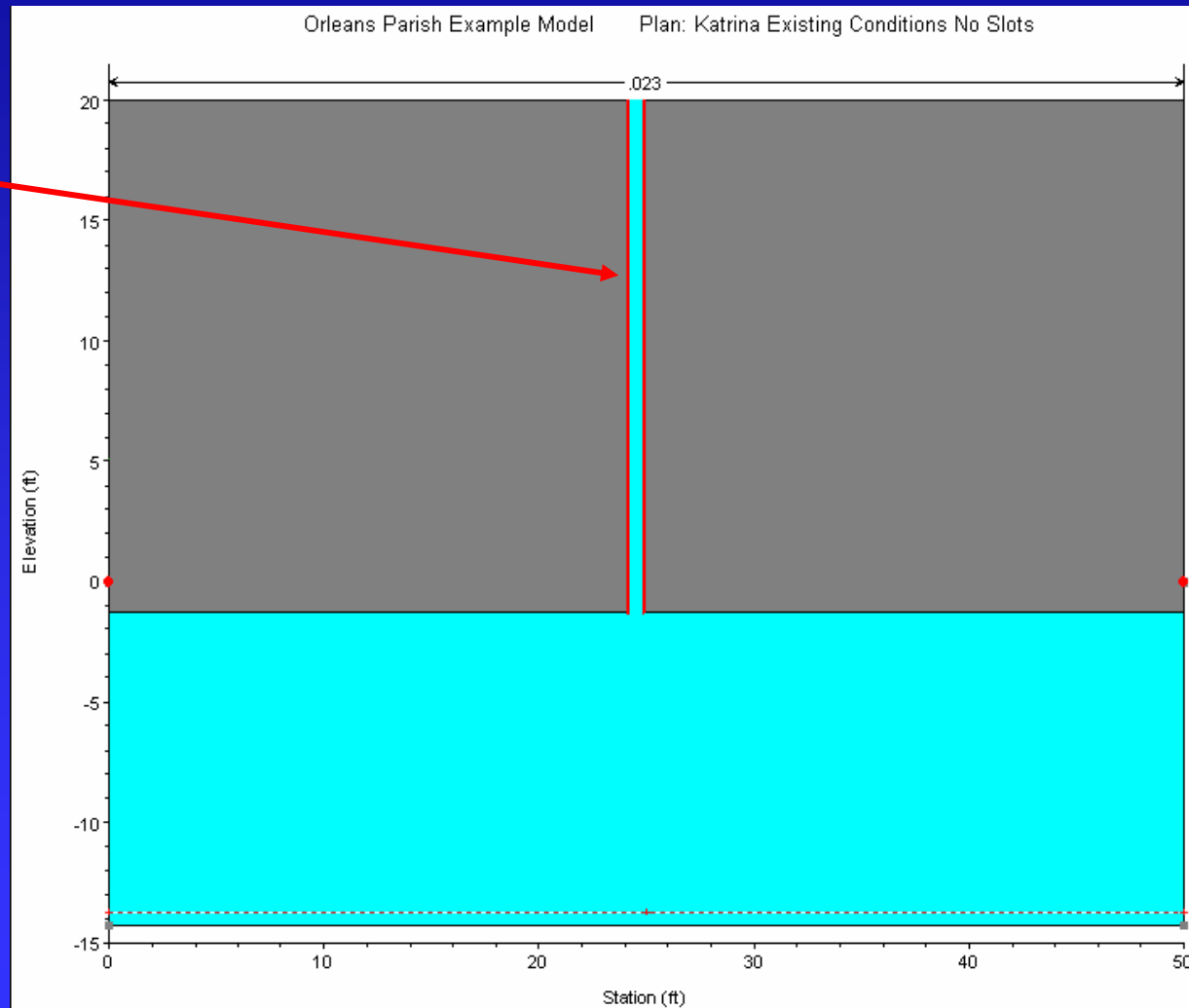
## Tampa Bay Water Project Hillsborough River – Harney Canal





# Pressurized Pipe Flow

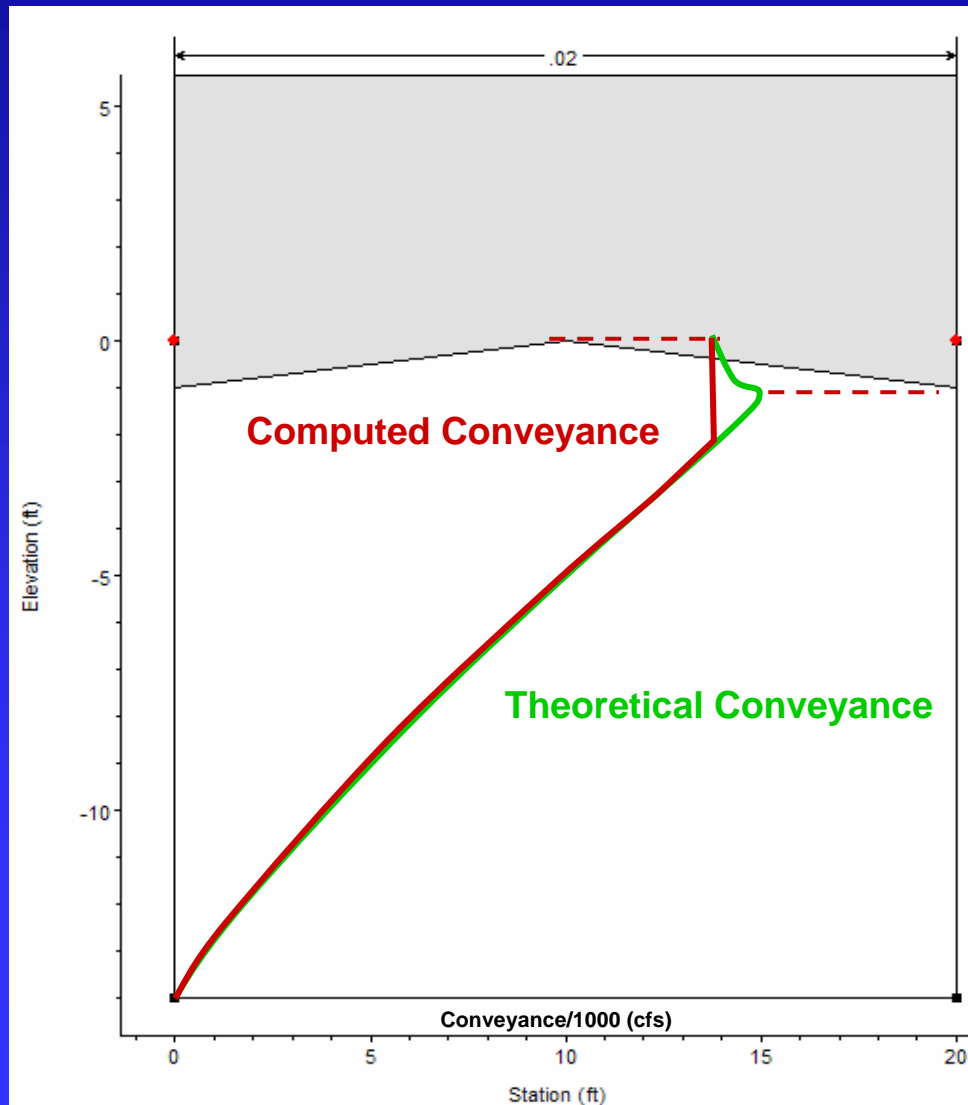
- **Priessman Slot** — insertion of an infinitesimal slot into the XS lid
- Any Pipe Shape
- Allows the water surface to rise to the pressure head (hydraulic grade line)





# Pressurized Pipe Flow

- Conveyance and wetted perimeter are cut off at top of pipe
- Area is added, but it is negligible
- Conveyance curve is truncated to local minimum to increase stability





# Pump Station Override Rules

**Pump Station Data Editor**

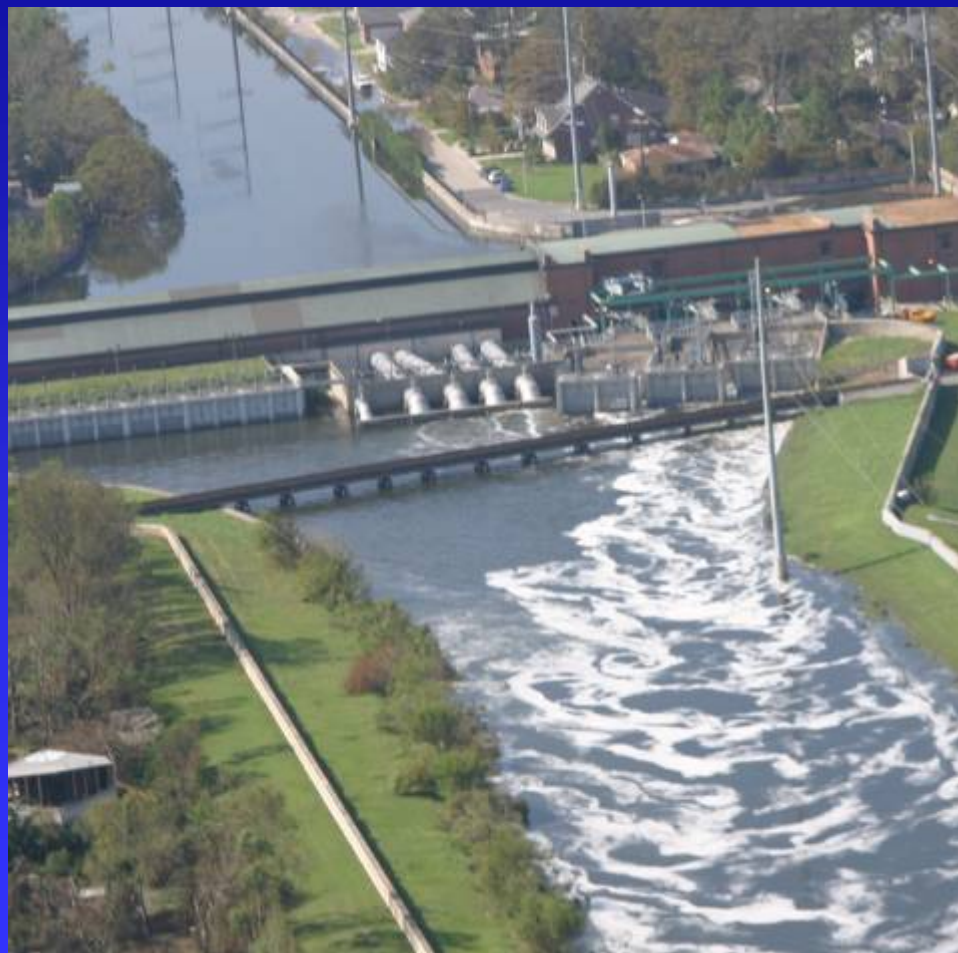
Pump Station Name: Pump15

**Pump Rules**

- Day/Hour based rule - flow max = 0 start at: 28AUG 0000 end at: 28AUG 1330
- Day/Hour based rule - flow max = 250 start at: 28AUG 1330 end at: 28AUG 1530**
- Day/Hour based rule - flow max = 750 start at: 28AUG 1530 end at: 28AUG 1545
- Day/Hour based rule - flow max = 500 start at: 28aug 1545 end at: 2aug 1600
- Day/Hour based rule - flow max = 0 flow min = 0 start at: 28AUG 1600 end at: 13SEP 0900

**Edit Current Selected Rule**

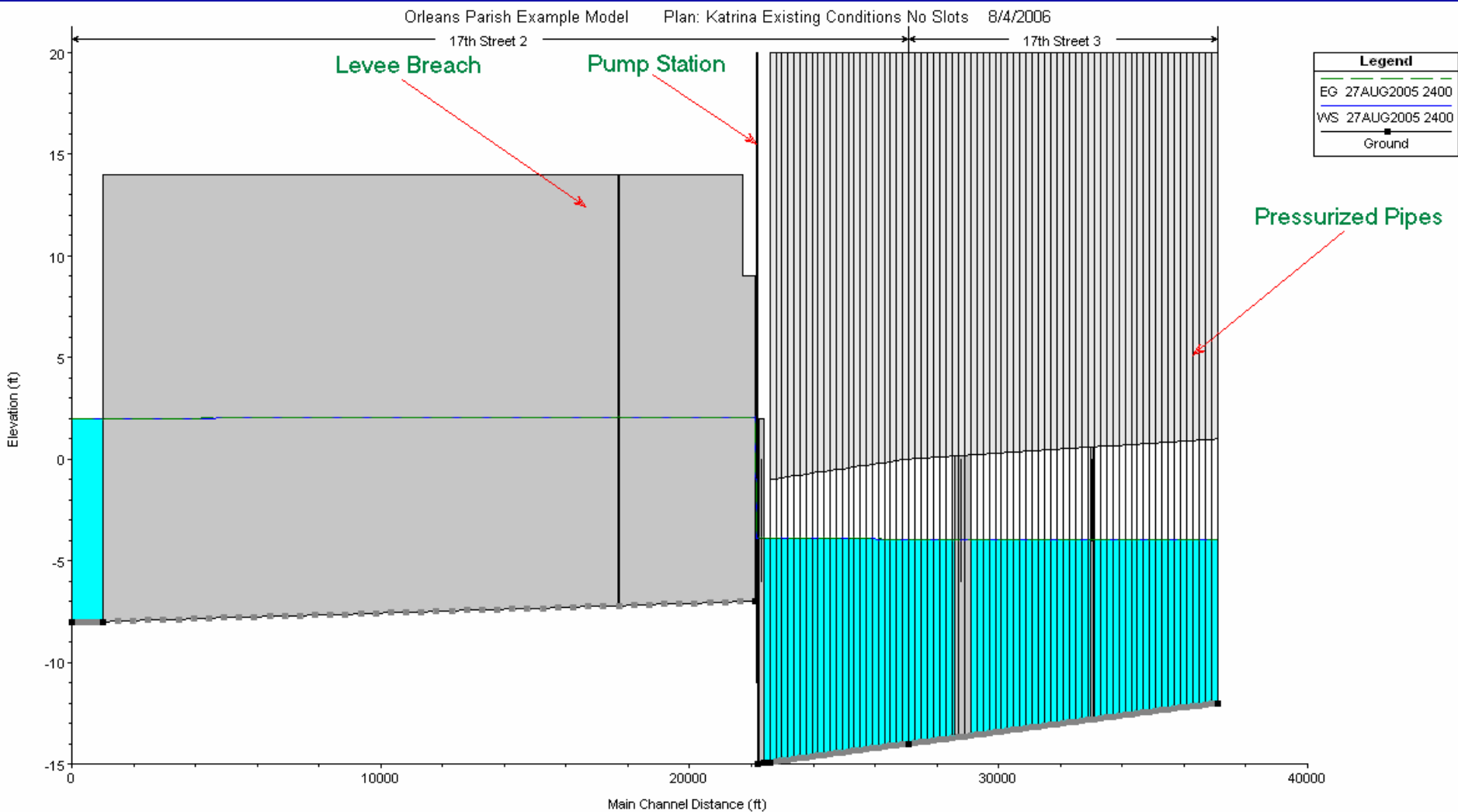
Rule Flow Maximum:	<input type="text" value="250"/>	Rule Flow Minimum:	<input type="text"/>
Transition (min):	<input type="text" value="5"/>	Transition (min):	<input type="text" value="5"/>
Rule Start Day:	<input type="text" value="28AUG"/>	Rule Start Hour:	<input type="text" value="1330"/>
Rule End Day:	<input type="text" value="28AUG"/>	Rule End Hour:	<input type="text" value="1530"/>



New Orleans - 17<sup>th</sup> Street Pump Station



# Pressurized Pipes, Pump Station, And Levee Breach Animation



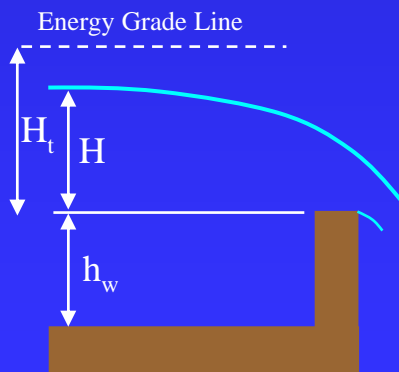


# Hager's Lateral Weir Equation

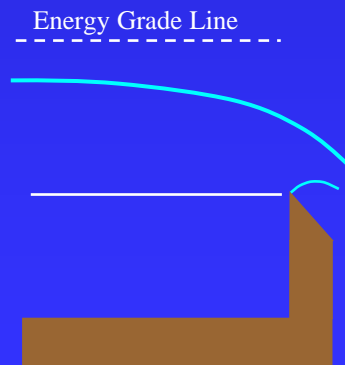
$$Q = CLH^{3/2}$$

$$C = \frac{3}{5} C_0 \sqrt{g} \left[ \frac{1-W}{3-2y-W} \right]^{0.5} \left\{ 1 - (\beta + S_0) \left[ \frac{3(1-y)}{y-W} \right]^{0.5} \right\}$$

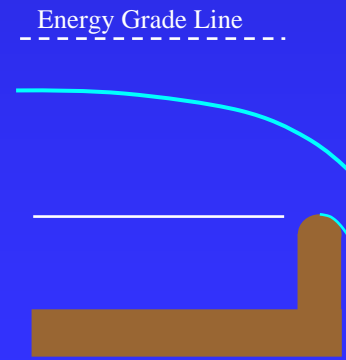
$$W = \frac{h_w}{H_t + h_w} \quad y = \frac{H + h_w}{H_t + h_w} \quad C_0 = \text{Function}(\text{weir shape})$$



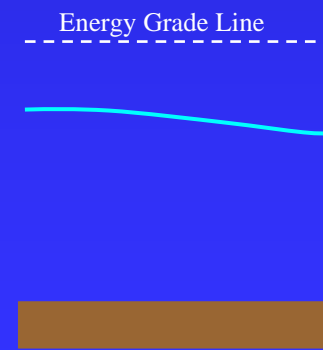
Broad Crested



Sharp Crested



Round/Ogee Crested

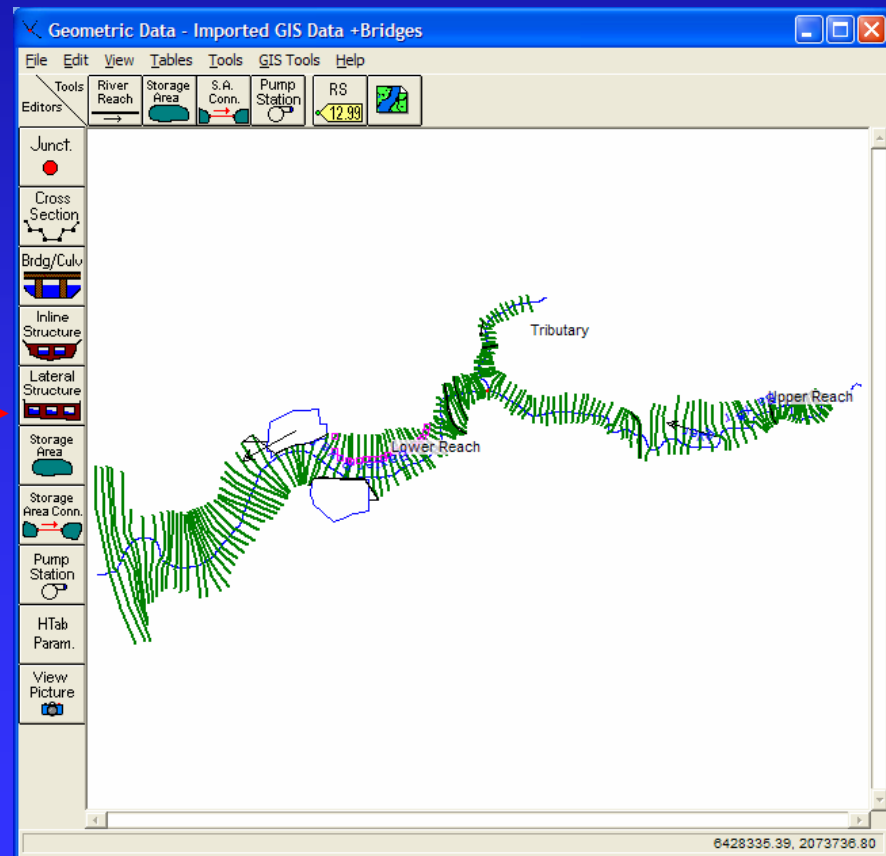
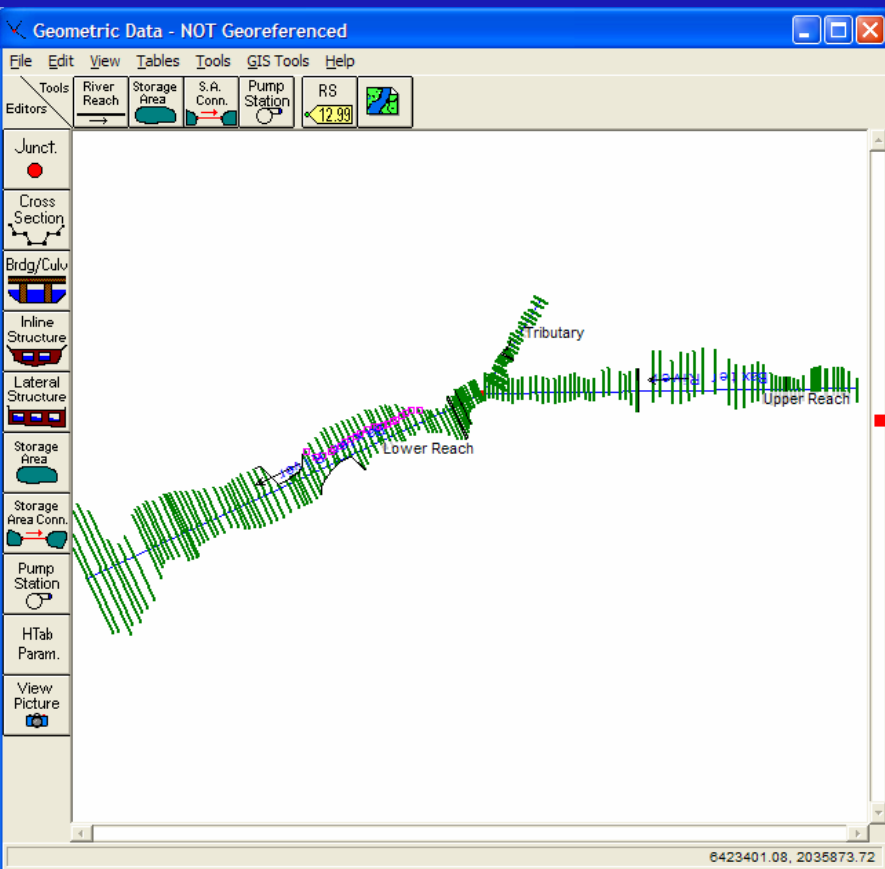


Zero Height Weir



# Geo-referencing Tools in HEC-RAS

- From “stick figure” to real locations

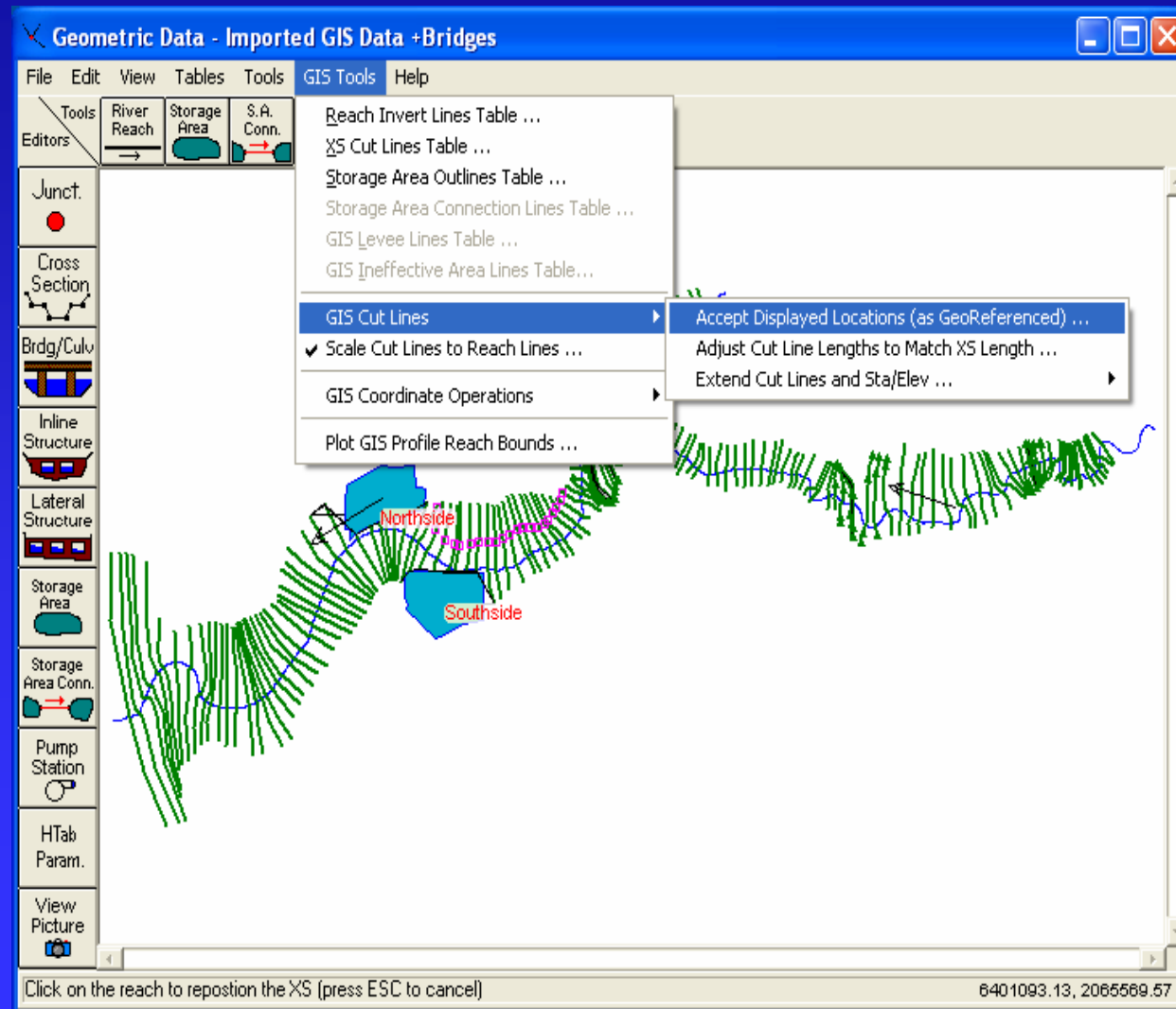






# Geo-referencing Tools in HEC-RAS

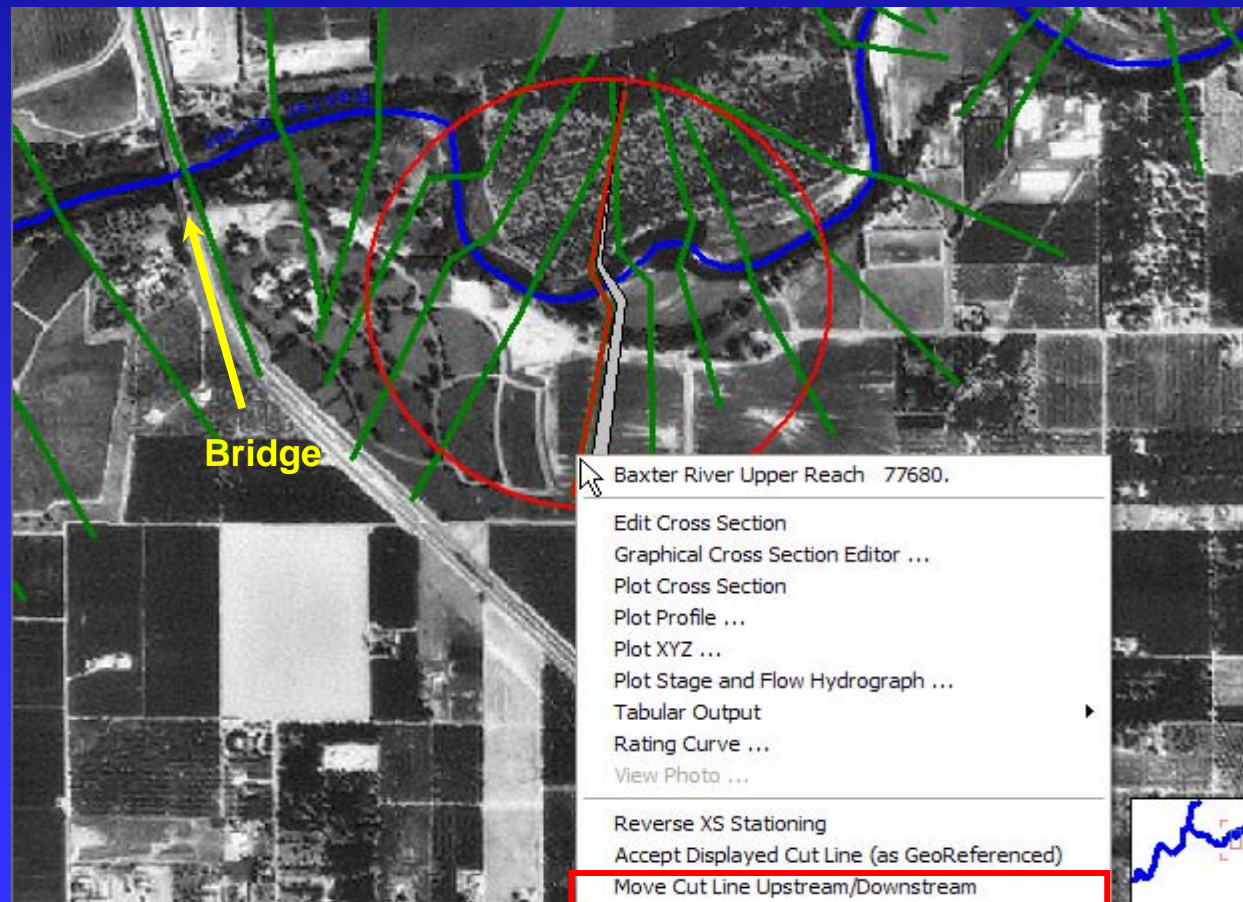
- Fix the cross sections at “known” locations
- RAS will help move the rest of the sections





# Geo-referencing

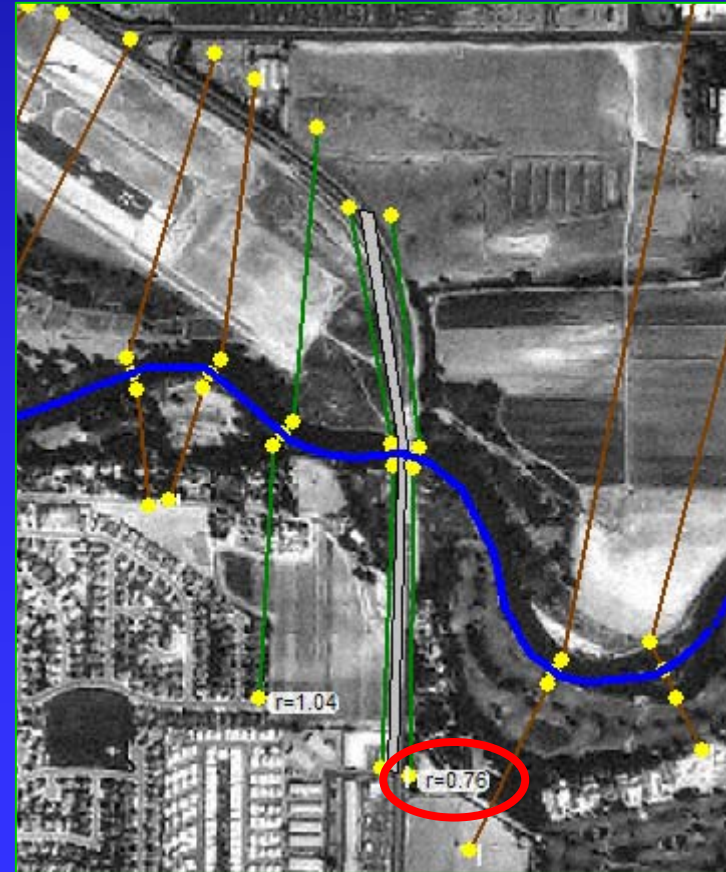
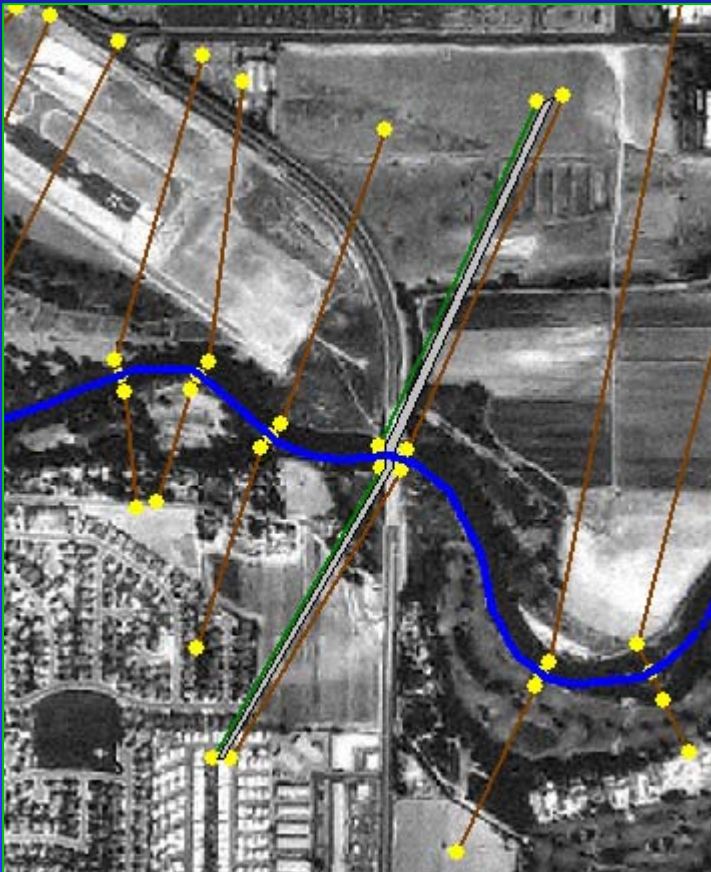
- Move Cut Line Upstream/Downstream





# Geo-referencing

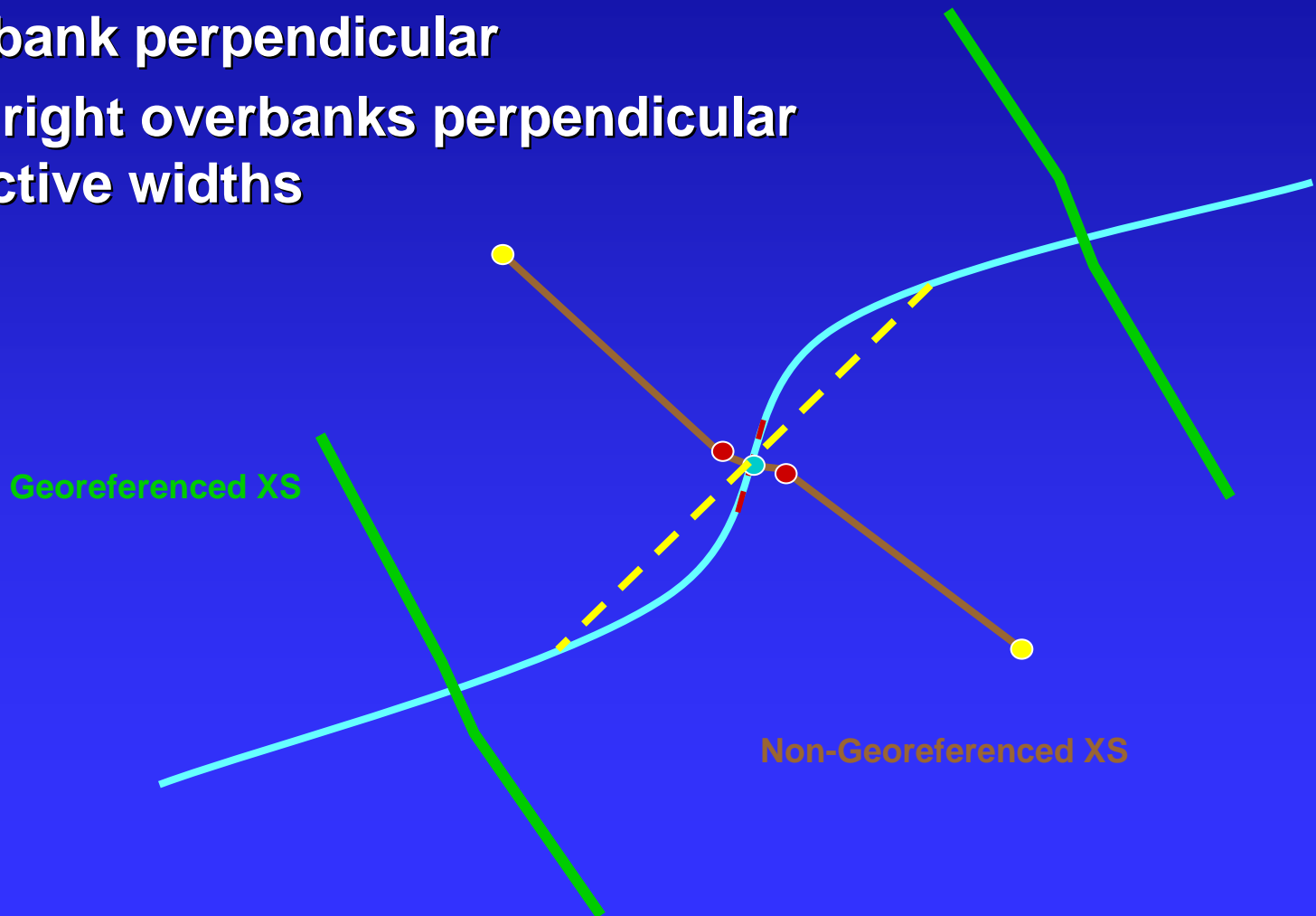
- Edit | Move Object





# Geo-referencing: New XS Interpolation

- Bank to bank perpendicular
- Left and right overbanks perpendicular to respective widths







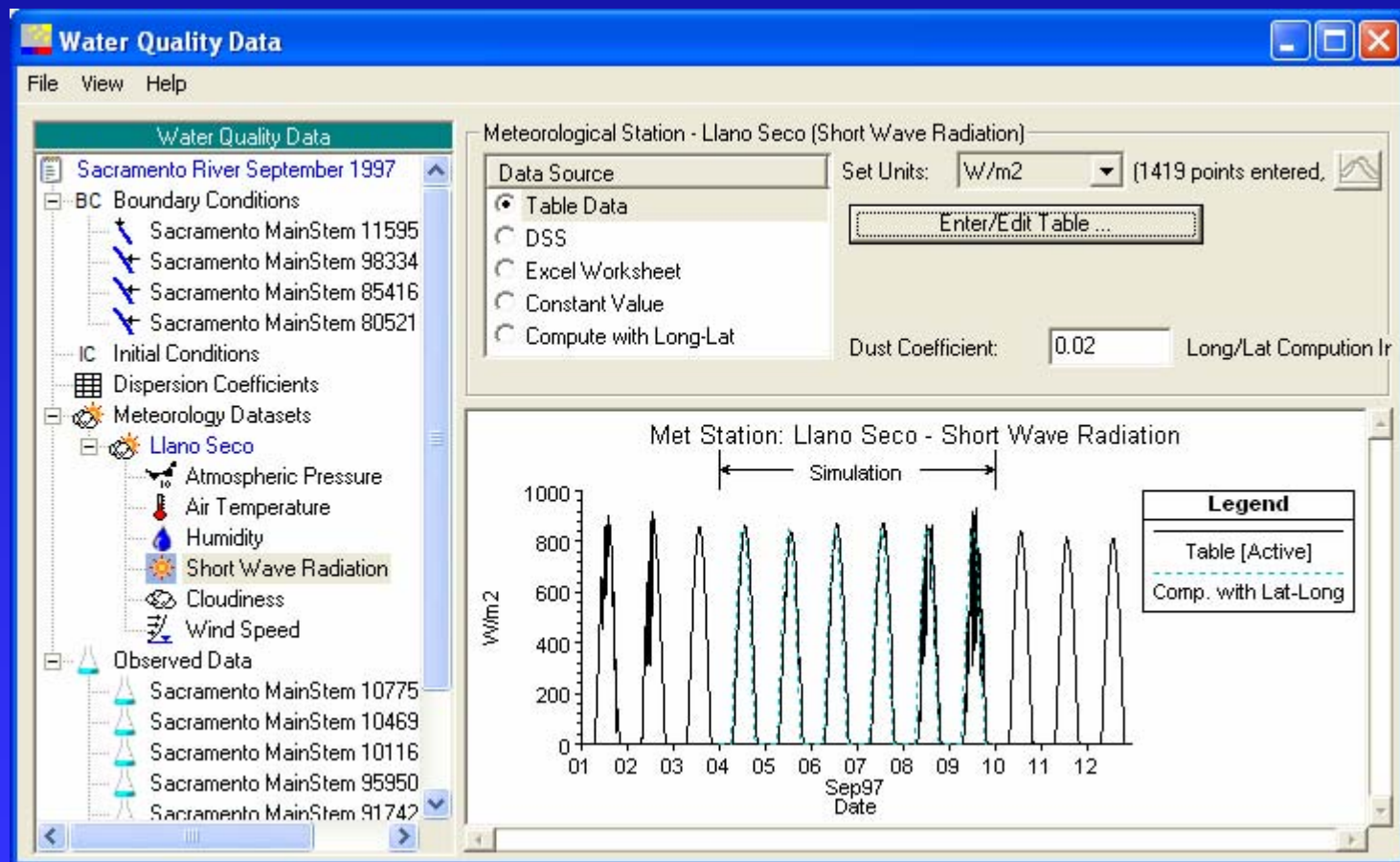
# Water Quality (Temperature) Model

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- Based on unreleased version of CE-QUAL-RIV1
- Numerical Scheme
  - ♦ Finite Volume
  - ♦ Variable grid size
  - ♦ Automatic time step selection
- Full energy budget

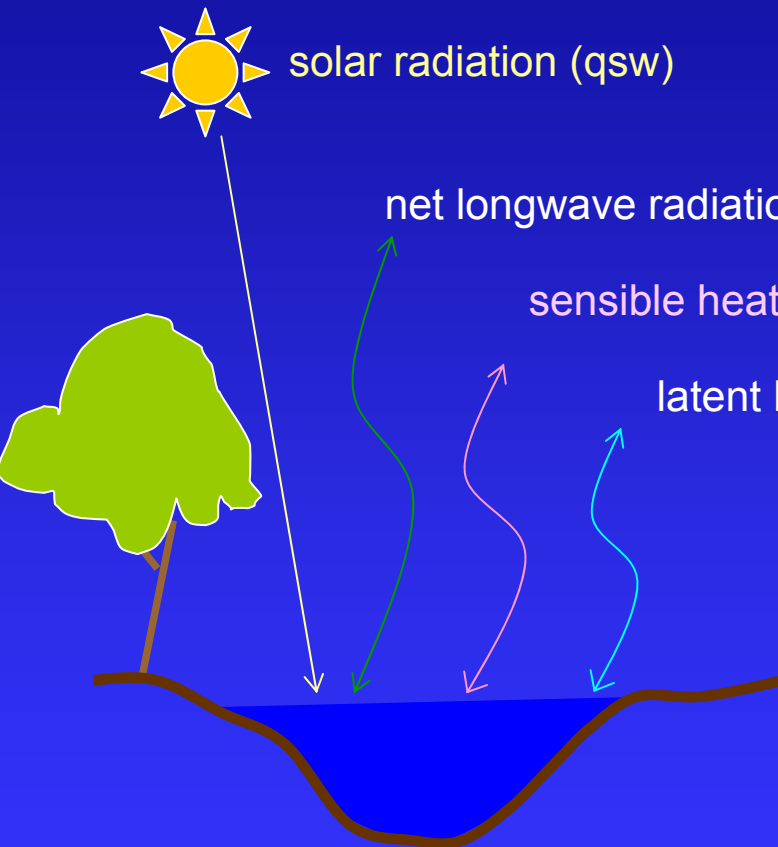


# Meteorological Data Editor – Solar Radiation





# Source/Sink Term for Temperature (Energy Budget)



solar radiation ( $q_{sw}$ )

$f$  (site location, time of day, day of year,  
atmospheric turbidity, cloud cover)

net longwave radiation ( $q_{lw}$ )

$f$  (air temperature, water temperature)

sensible heat ( $q_h$ )

$f$  (temperature gradient, wind, a&b)

latent heat ( $q_e$ )

$f$  (vapor pressure gradient, wind, a&b)

$$q_{net} = q_{sw} + q_{lwn} + q_h + q_e$$

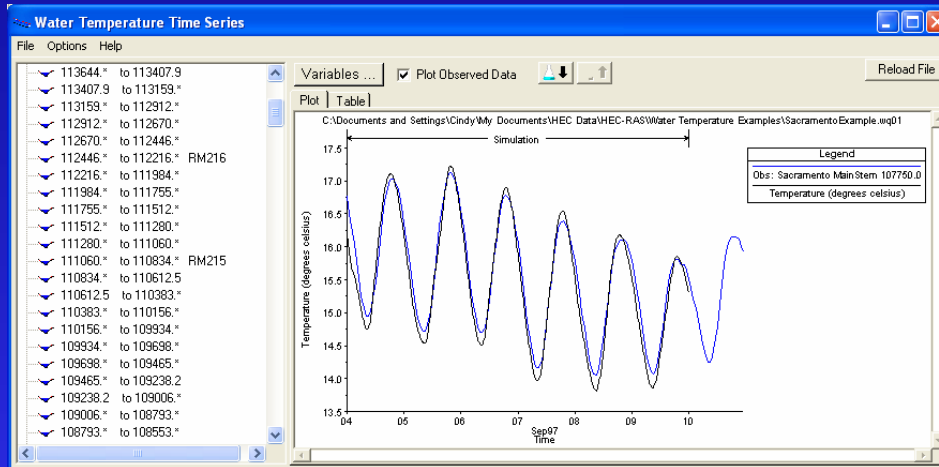
Planned:

- ground heat conduction
- shading (topographic, riparian)

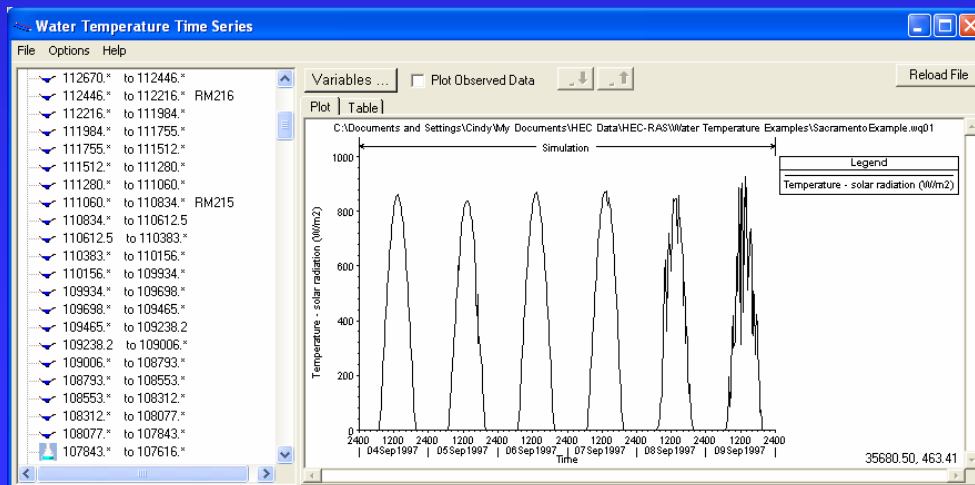


# Time Series Plots

## Water temperature



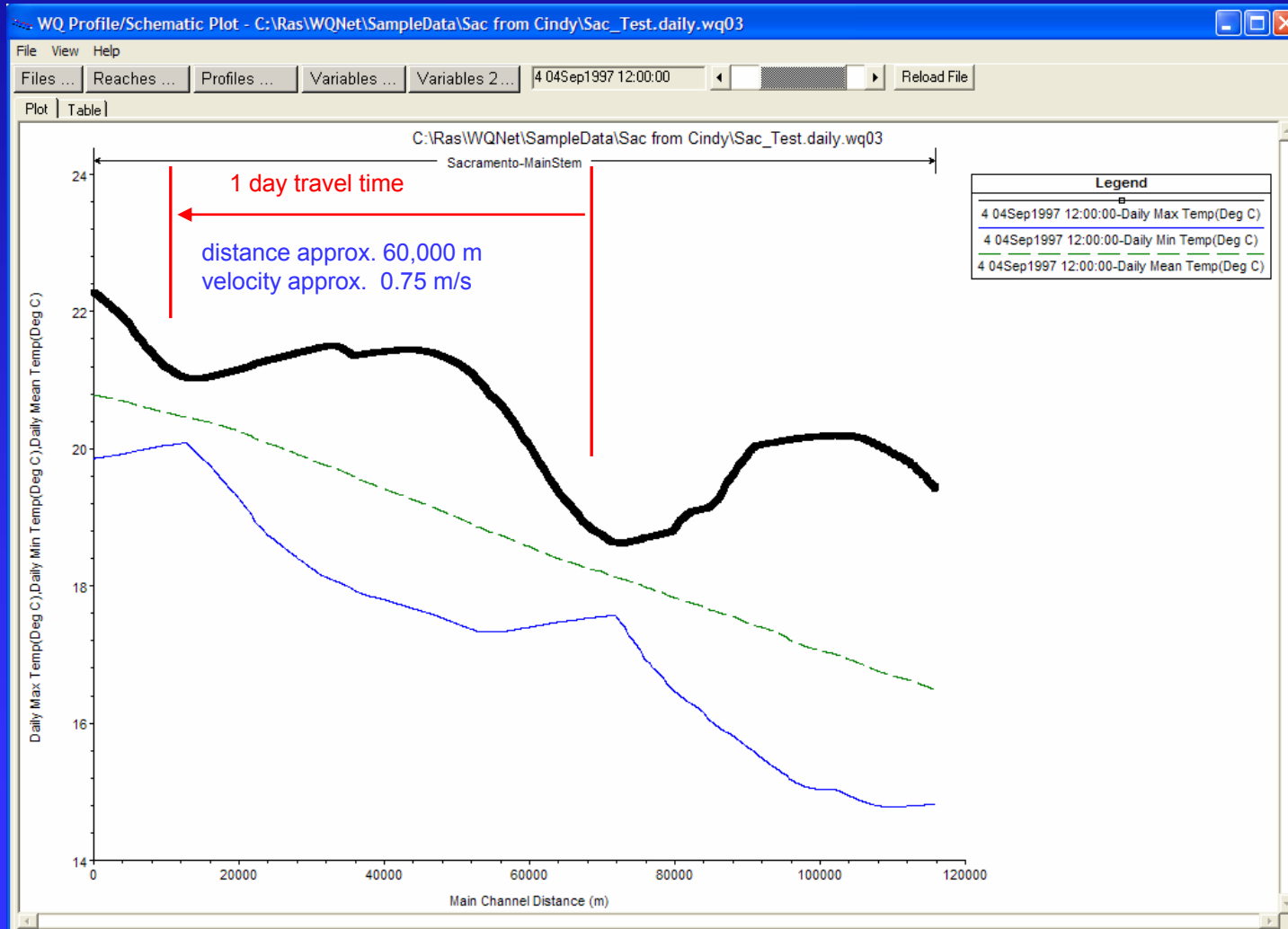
## Solar Radiation





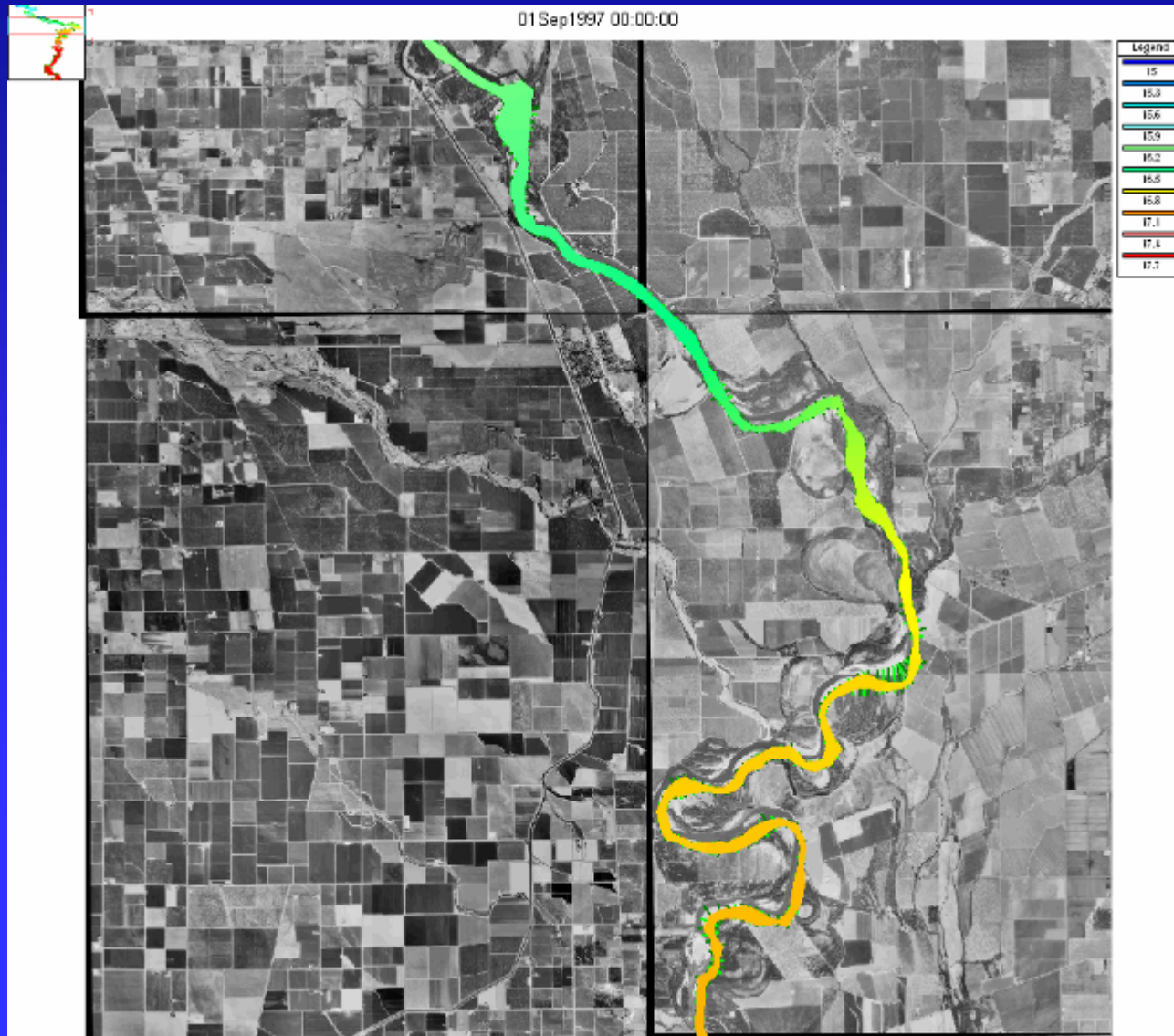


# Profile Plot of Temperature





# Map View





# Mobile Bed Sediment Transport

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- **Quasi-Steady Hydrodynamics**
- **Transport Capacity**
- **Sediment continuity**
- **Sorting and Armoring**
- **Erosion and Deposition**
- **Graphical User Design**



# Transport Potential Functions

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- Ackers-White
- Englund-Hansen
- Laursen (Copland)
- Myer-Peter-Meuler
- Toffaleti
- Yang (Sand and Gravel)
- Wilcock



# Transport Capacity by Multiple Grain Sizes

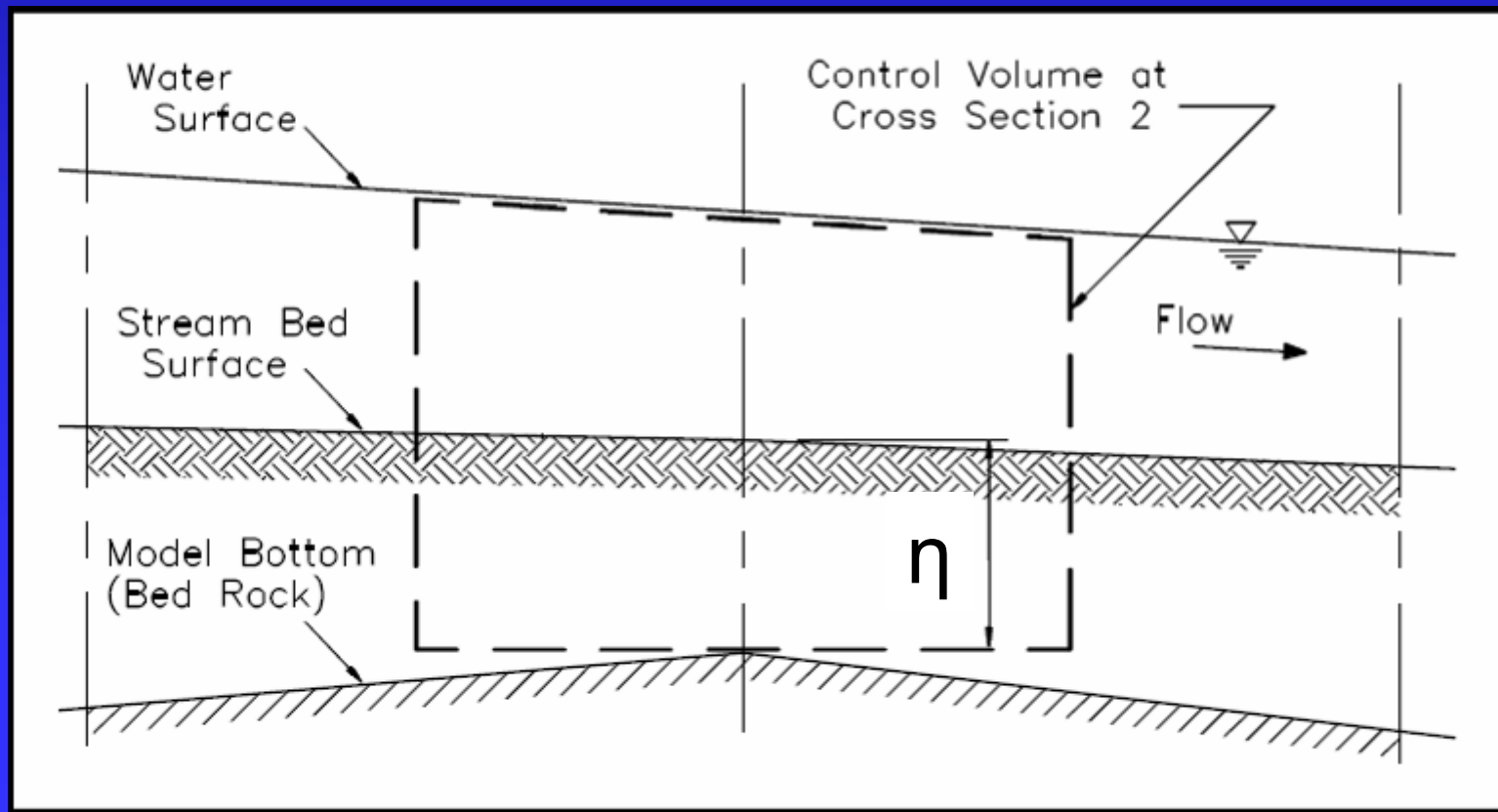
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- **Bed Material and Inflowing Load divided into separate grain classes (up to 20)**
- **Transport potential is calculated for each grain size**
- **Transport Capacity = (Transport Potential for each grain size) X (fraction of that material in active layer of bed)**



# Sediment Continuity: Exner Equation

$$(1 - \lambda_p) B \frac{\partial \eta}{\partial t} = - \frac{\partial Q_s}{\partial x}$$





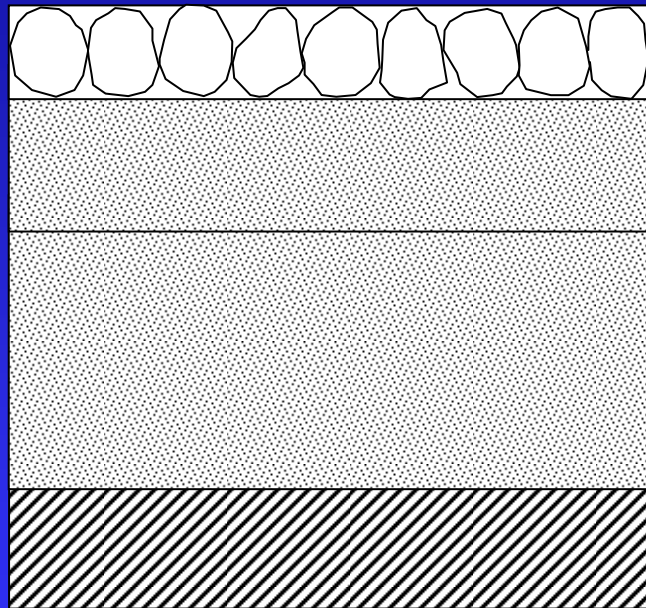
# Temporal Constraints on Eroding and Depositing

- Erosion and deposition does not occur instantaneously.
- Deposition is based on settling velocity:
  - ♦ Deposition efficiency coefficient = 
$$\frac{V_s(i) \cdot \Delta t}{D_e(i)}$$
- Erosion is based on “Characteristic Flow Length”
  - ♦ Erosion =  $(G_s - Q_s) \times C_e$  Entrainment Coefficient
  - ♦ Where:

$$C_e = 1.368 - e^{\frac{L}{30 \cdot D}}$$



# Sorting and Armoring



Cover Layer

Subsurface Layer

Inactive Layer

Bedrock Layer

Active  
Layer

**Diagramed and  
Conceptualized  
HEC 6 Code**

**Exner 5  
implemented  
Currently in RAS**

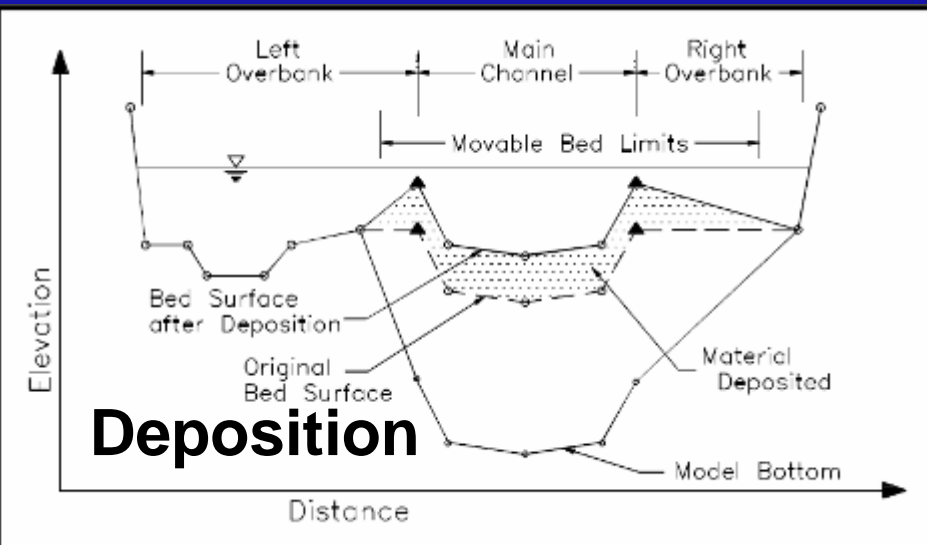
**Also Simple  
Active Layer  
Method**

\* Erosion can be further constrained by the cover Layer



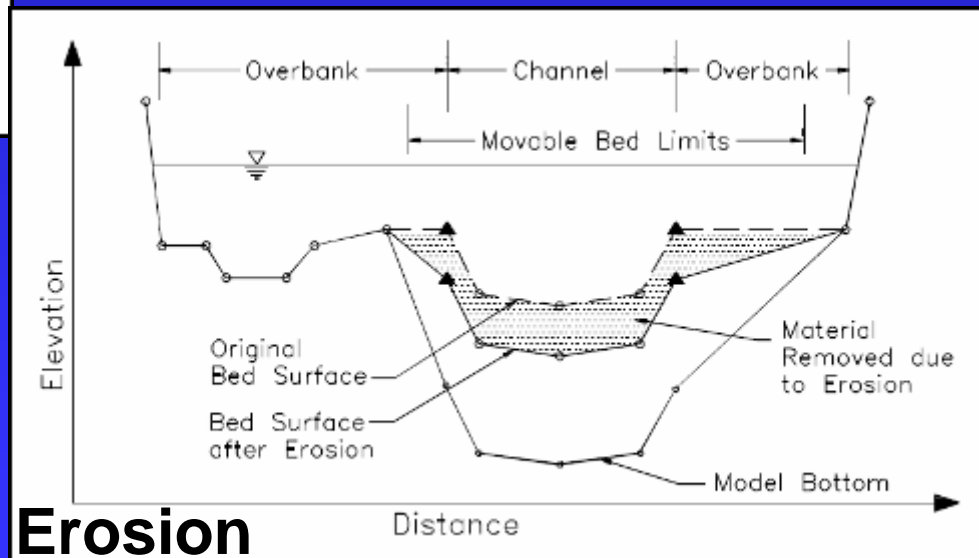


# Erosion and Deposition to RAS Cross Sections



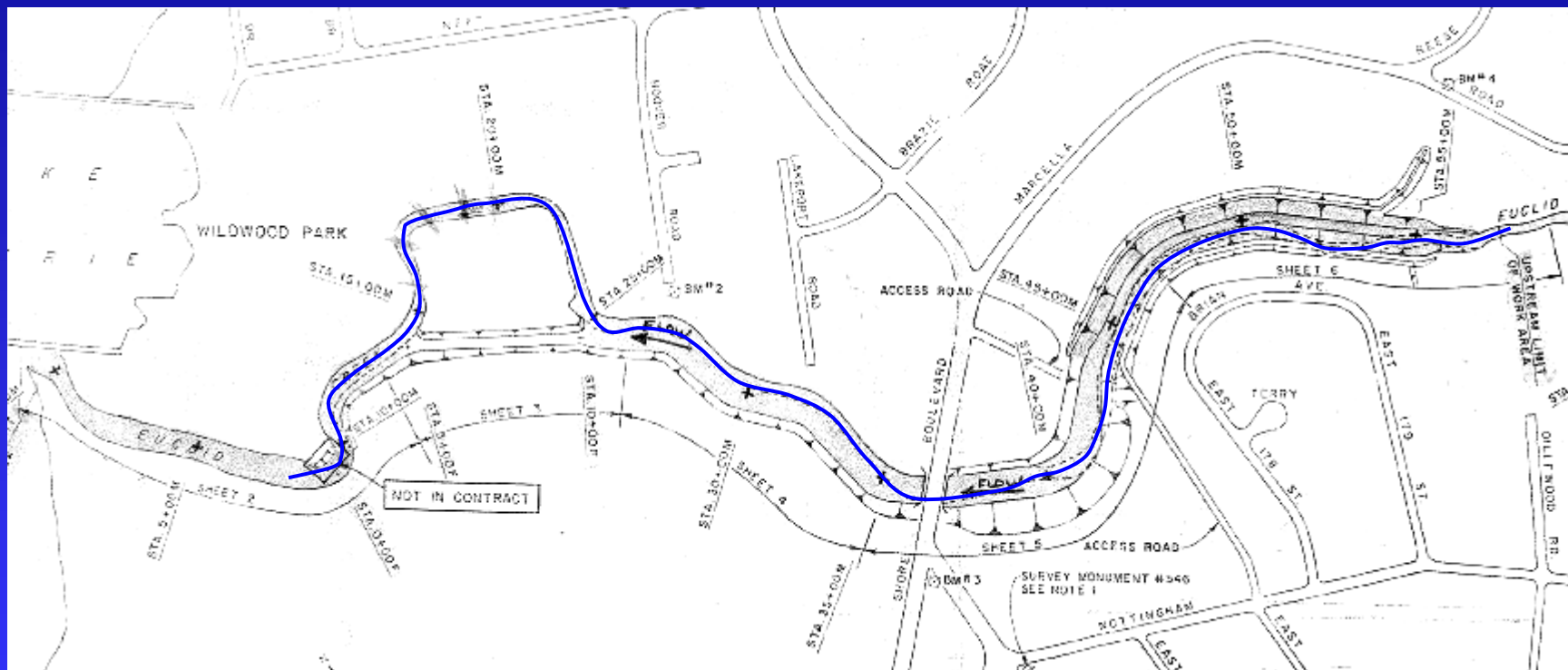
- Cross Sections
- Bridges

**RAS computations modified  
to compute bed changes and  
modify cross sections before  
each time step**





# Example Application: Euclid Creek





# Case Study: Euclid Creek







# Case Study: Euclid Creek





# Case Study: Euclid Creek

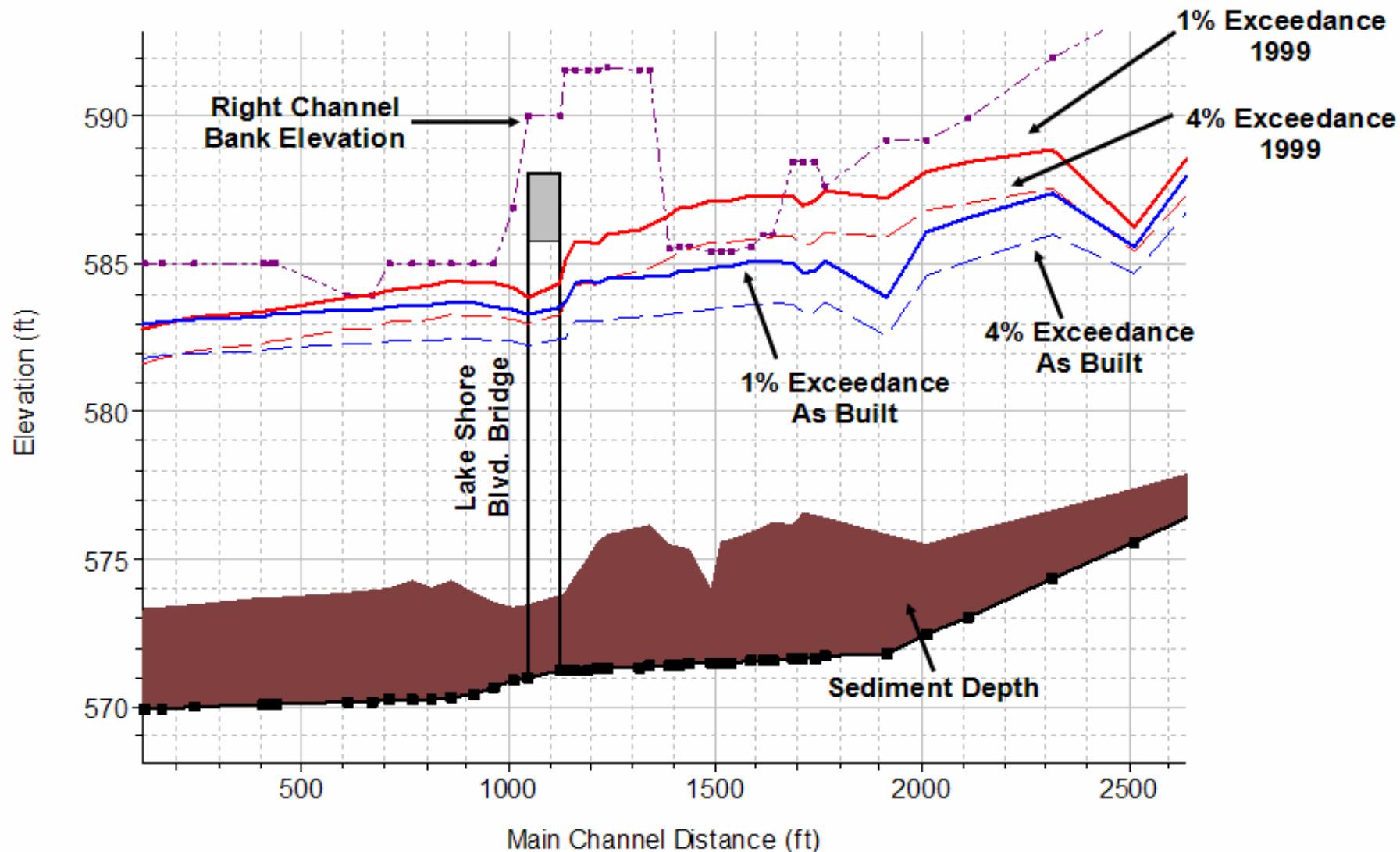
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# Case Study: Euclid Creek





# Animation of Bed Movement

